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June 20, 2007

Dr. Thomas Granda
Federal Highway Administration
Office of Safety R&D, Human Centered Systems
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101
Via email

Reference: Contract DTFH61-01-C-00049, Task Order 28
Driver Use of En Route Real-Time Travel Time Information
Westat Project 7629.28

Dear Dr. Granda:

This letter report provides the Task 2 (literature review) deliverable for the above-referenced project. It summarizes research, guidance, and current practice regarding the provision of roadway-based real-time travel time information.

The findings are provided in two attachments, which are described below. This summary is based on a review of published literature, internet scans, and expert contacts.

Project Background and Purpose

Travel time is one of the most important pieces of information that can be given to motorists. Communications and display technologies now exist that permit the provision of key travel information to drivers in real time. Travel time, speed, or delay information is typically given by destinations or roadway segments, using changeable message signs. Such real-time travel time displays are increasingly used in the United States, and more extensive use and innovative displays are seen in other countries. Travel time information has the potential to improve driver decision making, resulting in benefits to individual travelers and improved performance of the roadway system. There does not currently exist a good empirical basis, or adequate design guidance, for providing information in a way that most effectively aids motorists. The information provided must be useful, understandable, timely, credible, and safely used, and should result in predictable effects on route choice and route diversion.

The purpose of this project is to conduct human factors research to establish a basis for effective provision of real-time travel time information. The focus is on the presentation of estimated travel time, or related information such as travel speed, delay, or congestion level, in real time to motorists via changeable message signs. Such systems will only work well if they are designed with consideration of driver information needs and an understanding of the driver decision process. Motorists must receive the type and amount of information that they need and can process effectively while driving. This project will

conduct empirical research to better understand and quantify driver response and determine the factors related to display effectiveness. The Task 2 literature review presented in this letter report provides a basis for developing a specific research approach and experimental plan (Task 3), which may include laboratory, simulator, instrumented vehicle, and other methods.

Information Search Activities

Keyword searches and scans of key journals and reports were used to identify available literature relating to the human factors aspects of real-time provision of travel time information. Two major FHWA research programs provided substantive literature reviews in the late 1990's (Campbell, Carney, and Kantowitz, 1998, *Human Factors Design Guidelines for Advanced Traveler Information Systems (ATIS) and Commerical Vehicle Operations (CVO)*; Lerner, Llaneras, and Huey, 2000, *Analysis of Travelers' Preferences for Routing: Final Report*). The present review took those reviews as a starting point and focused its search activities primarily on literature from the past ten years. More than 130 documents were acquired and reviewed for relevant information.

The project also sought information on current practices and rationale regarding the use and display of travel time information in the United States. This was accomplished though internet searches and through formal requests for information. While the resulting summary cannot be deemed completely comprehensive, we identified a very broad range of jurisdictions providing travel time information and which use a variety of different practices.

The request for information on current practices was distributed to States participating in the Pooled Fund Study (PFS) program, and to the Transportation Research Board (technical committees AND20 User Information Systems, AHB15 Intelligent Transport Systems, AHB20 Freeway Operations), Institute of Transportation Engineers (Management and Operations/ITS Council), and American Association of State Highway and Transportation Officials (Standing Committee on Highways). The request briefly described the project and its interests and specifically indicated interest in the following sorts of information:

- Any research or evaluation on this topic, including unpublished or informal studies
- Examples of implementation of real-time travel time systems
- Practices and policies on what to display and how to display it
- Available guidance or standards on the topic
- People or agencies that may be especially knowledgeable or have unique information (with contact information if you have it)
- Any thoughts you might want us to consider in the course of conducting this information search

The responses to the information request were supplemented with information and contacts identified in another on-going project that included some consideration of travel time information provision, NCHRP Synthesis 20-5/Topic 38-11, *Dynamic Message Sign Displays During Non-Incident, Non-Roadwork Periods*. We thank Dr. Conrad Dudek, who is conducting that project, for generously sharing the information he assembled. We also thank Jimmy Chu from the FHWA Office of Transportation Management for sharing his knowledge of ongoing activities in this area.

The findings of this information search are summarized in two attachments to this letter. The first (Attachment A) is a matrix that summarizes current U.S domestic practice, as we were able to identify it. It shows the jurisdictions that are providing on-road real-time travel time information and indicates key features of many jurisdictions' practices. Associated with this matrix is a set of photographs and images that illustrate the travel time displays for many jurisdictions. The second attachment (Attachment B)

provides the summary findings of the full information search. It includes findings and opinion from published research and expert contacts. The findings are organized around a broad set of research questions.

Summary of Current Domestic Practice

Attachment A lists jurisdictions that were identified as providing on-road real-time travel time information as of June, 2007. For each of the 32 jurisdictions, the matrix indicates the location, type of information provided, means of presenting the information, and other details. As a supplement to this table, illustrative photographs or images related to many jurisdictions are provided in an attached file. The matrix in Attachment A shows the diverse range of practices currently used in the U.S. as well as the limitations to current practice. For example, in contrast to some other countries, the U.S. does not appear to make use of dedicated travel time displays, diagrammatic displays, or congestion coding. The discussion of particular practices identified in the table are integrated into the summary of findings in Attachment B.

Summary of Key Issues and Related Findings

A primary purpose of the Task 2 information search is to provide a basis for the selection of the research questions that will be addressed in the experimental research phase of this project. A number of key questions were identified in the Task Order Statement of Work and in the proposal for this project. Additional questions emerged in the course of the literature review and expert discussions. We used these questions as a means of structuring the findings of the information search. Attachment B provides the summary. The findings are organized under headings representing major human factors issues in travel time reporting. Below each heading are human factors questions relevant to the topic and findings related to each question in the form of research results, guidelines, current practice, and expert opinion and experience. In some cases, no findings were identified for particular questions.

Subsequent to FHWA review and comment on this letter report, Westat will derive the preliminary set of research questions to be addressed in the research phase and develop a draft research work plan. This will then be circulated for review and discussion by FHWA and PFS participants. Therefore we hope the reviewers of this letter report will consider whether there are any important issues which may not have been explicitly identified.

Sincerely,

Neil Lerner
Project Manager

ATTACHMENT A:

SUMMARY MATRIX OF CURRENT U.S. TRAVEL TIME PRACTICES

Table of Contents

Matrix of Travel Time Program Characteristics

State	Location	Hours of Operation	Travel time	Delay time	Average speed	Road name	Exit number	Landmark / town	Distance	Vary destinations	Travel time range	Time identifier	Target destination distances	Travel time on alts	Travel time on separated roads	Time of most recent update	Update frequency	Banner text	Use of second phase	Max # of destinations
CA	Bay Area (dist 4)*	0500-2100 daily	Y								1	MIN	4-20 mi	Y	N		60s	TRAVEL TIME TO[b]		3
CA	Los Angeles & Ventura Cos. (dist 7)*	0500-1900 M-F	Y								1	MIN			N		180s	TRAVEL TO; none[a]	N	2
CA	Inland Empire (dist 8)		Y								1	MIN			N			MINUTES TO		2
CA	San Diego (dist 11)		Y								1	MIN			N			TRAVEL TIME TO	N	2
CO	statewide		Y																	
DE	Wilmington																			
FL	Jacksonville																			
FL	Orlando (I-4)	24/7	Y			Y		Y	Y		1	MIN		Y				none	travel time	2
GA	Atlanta*	0600-1100 M-F; 0800-1000 Sat-Sun; and when congested	Y		Y[c]	Y	Y		Y[d]		2-3	MIN	5-15 mi		HOV			uses destination rd/exit as banner; "TRAVEL TIME:" shown at bottom[e]	on smaller arterial CMS only	
IL	Chicago*	0500-1000, 1500-1900 M-F; and when congested[f]	Y			Y		Y			1	MIN		Y	express/local			none[g]	travel time, various	3
IN	northwest corner																			
KY	Louisville																			
LA	Baton Rouge*		Y			Y			Y		3	MIN						none (destination is top line)		
MI	Detroit																			
MN	Minneapolis																			
MO	Kansas City* & St. Louis	0600-1000, 1500-1900 M-F; and when congested	Y			Y		Y	Y		1	MIN						none	incident	3
NC	Raleigh																			
NY	New York City																			
OH	Cincinnati																			
OH	Columbus																			
OR	Portland*	only when congested	Y								3-5[h]	MINS	3-15 mi					TRAVEL TIME TO	N	
TN	Knoxville																			
TN	Nashville*	24/7	Y					Y	Y		3	MIN						none		1
TX	Dallas		Y			Y					2	MINUTES						TRAVEL TIME TO		
TX	Fort Worth		Y			Y														
TX	Houston*	0530-1930 daily; and when congested	Y			Y		Y			1	MIN		Y		Y	600s	TRAVEL TIME TO	N[i]	
TX	San Antonio*	0600-2200 daily	Y			Y		Y			3	MINS	5-10 mi, mostly					TRAVEL TIME TO	incident/congest	
UT	Salt Lake City*	0600-0900, 1530-1900 M-F	Y			Y					1	MIN					60s	TRAVEL TIME		2
VA	Hampton Roads																			
WA	statewide*	Rush hour	Y																	
WI	Milwaukee*	24/7	Y					Y[j]	Y	Y	1	MIN	3-23 mi	Y	N		60s	FREEWAY TIME TO[l]	incident/congest	

*See photos and images of travel time signs following this table.

[a] Two-line CMS eliminate the header due to lack of space.

[b] When providing travel time to a single destination, Bay Area CMSs uses TIME TO as the banner (signs may be smaller than full size.

[c] Atlanta displays average speed on freeways, but apparently only on two-phase arterial signs prior to freeway entrance.

[d] Atlanta's signs that show travel time via two routes do not include distance to destination.

[e] If space is limited, TRAVELTIME is displayed as a single word.

[f] Webb (2004) suggests that travel times are shown 24/7 in some locations.

[g] Although 2005 report shows "TRAVEL TIMES TO" as banner, current practice appears to include no banner.

[h] 5 minutes is used during periods of congestion when travel time predictability is low.

[i] Houston occasionally multi-phases travel time info if other important information exists.

[j] Though Wisconsin's VMS guidelines recommend against using landmarks, they are used when landmarks is more meaningful to drivers than road names.

[l] Milwaukee area also has arterial CMS that display freeway travel time using the format "I-94 TRAVEL TIME."

Matrix Legend

Hours of operation. Indicates hours when travel times are displayed on CMS (using 24-hour time) and days of operation.

Travel time, delay time, average speed. These columns indicate which type(s) of real-time traveler information is provided on CMS.

Road name, exit number, landmark / town, distance. These columns indicate which types of information is used to define a destination on a travel time CMS. 'Distance' means the distance to the destination.

Vary destinations. This column indicates whether travel time destinations on CMS are changed at different times of day, days of the week, etc.

Travel time range. This column indicates whether travel time signs provide a single number as a travel time estimate or a range of time, where, for example, 2 means a two-minute range (e.g., 8-9 minutes).

Time identifier. The text used to represent 'minutes' on travel time CMS.

Target destination distances. The range (in miles) of typical distances from travel time CMS to destinations.

Travel time on alts. Indicates whether travel times are provided to destinations on roads other than the current road.

Travel time on separated roads. Indicates whether travel times are provided specifically for particular lanes on a road (e.g., HOV, HOT, express versus local).

Time of most recent update. Indicates whether travel time messages include the time that travel time was last updated.

Update frequency. Indicates how often travel times are recalculated.

Banner text. The header information presented in the top line of travel time CMS, if any.

Use of second phase. Indicates whether travel time CMS may include a second phase of information, whether related to travel time or not.

Max # of destinations. The maximum number of destinations presented on a single travel time CMS.

Collection of Travel Time Sign Photos and Images

California – Bay Area (Caltrans District 4)

Margulici (2006):

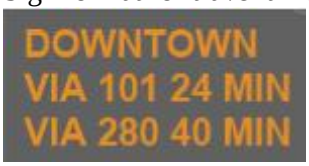
Travel time format (Caltrans, 2006):

TRAVEL TIME TO	
RTE 92	XX MIN
SFO ARPT	XX MIN

SF DWNTWN	XX MIN
SFO ARPT	XX MIN
OAK ARPT	XX MIN

TIME TO RTE 92 XXX MIN
TIME TO RTE 280 XXX MIN

Sign format for travel times on alternate routes (Margulici, 2006):



California – Los Angeles & Ventura Counties (Caltrans District 7)

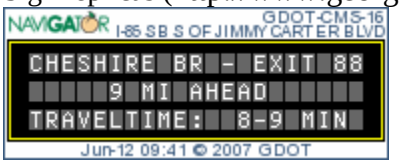
Photos courtesy of Jeff Aragaki:

Hoops & Gallegos (2006):

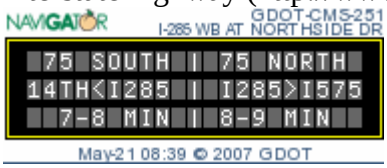
Georgia – Atlanta

Atlanta travel time sign (Meehan & Rupert, 2004):

Sign replicas (http://www.georgia-navigator.com/signs):



Sign replicas showing travel times (top) and speeds (bottom) in both directions of a nearby interstate highway (http://www.georgia-navigator.com/signs):



Illinois – Chicago

Illinois Department of Transportation, 2005:

Chicago travel time sign messages (unformatted) (gcmtravel.com):

5 MIN TO MONTROSE
16 MIN TO O'HARE

36 MINUTES TO
CIRCLE
VIA KENNEDY

Phase 1:

10 MINUTES TO
MONTROSE
VIA KENNEDY

Phase 2:

25 MINUTES TO
O'HARE
VIA KENNEDY

Phase 1:

CERMAK TOLL 20 MIN
DNTWN VIA 290 32 MIN
DNTWN VIA 90 52 MIN

Phase 2:

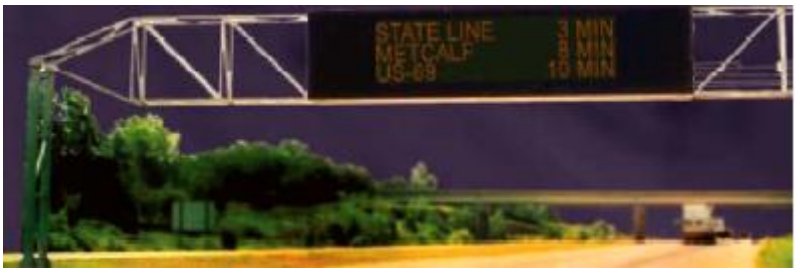
TRUCKS
USE
2 RIGHT LANES

Louisiana – Baton Rouge

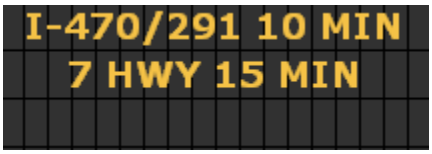
Baton Rouge travel time sign (Louisiana Department of Transportation and Development, 2007):

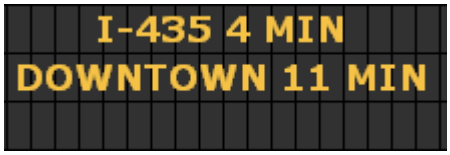
Missouri – Kansas City

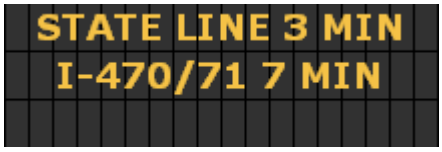
Digitally altered photographs (KC Scout web site):



Electronic replicas of Kansas City travel time signs (KC Scout web site):

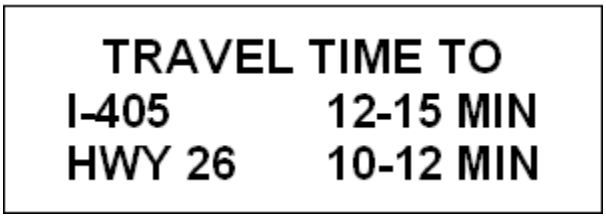






Oregon – Portland

Portland travel time sign format (Oregon Department of Transportation, 2005):

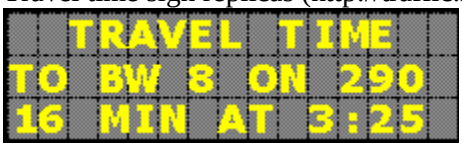


Tennessee – Nashville

Nashville travel time sign (top) and replica (bottom) (TDOT, 2005):

Texas – Houston

Travel time sign replicas (http://traffic.houstontranstar.org/dms/dmstext.aspx):



Texas – San Antonio

San Antonio travel time sign (top), replica of a two-phase travel time message (middle), and combined congestion/travel time message (bottom) (Strain, 2005):

Phase 1:

Phase 2:

from http://www.transguide.dot.state.tx.us/TravelTimes/signs.php :

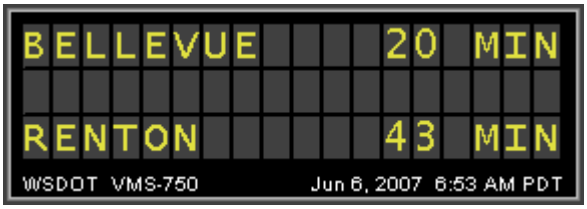
Utah – Salt Lake City

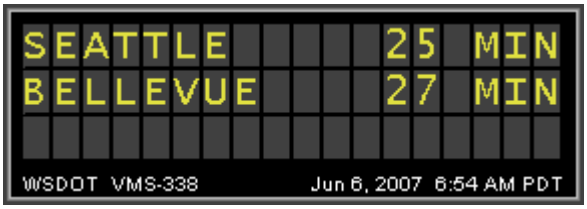
Utah travel time sign replica:

Washington – Seattle

Seattle area travel time sign:

Seattle area travel time sign replicas (http://www.wsdot.wa.gov/traffic/seattle/vms/):





Wisconsin – Milwaukee

Langer, 2005:

Recommended format for travel times on alternate routes (Wisconsin Department of Transportation, 2006):

FREEWAY TIME TO AIRPORT	
VIA I-894	15 MIN
VIA I-94	18 MIN

ATTACHMENT B:

REAL TIME TRAVEL TIME RESEARCH QUESTIONS

Table of Contents

Audience for Travel Time Information

1. Who is the audience for travel time information?
    - Portland identified 4 classes of driver: local commuter, local non-commuter, non-local commuter, non-local non-commuter. Officials decided that local commuters would be the primary audience for travel time information and designed system accordingly (Oregon Department of Transportation, 2005).
    - Forth Worth designs travel time signs to accommodate local drivers because 90% of traffic on roads during rush hours is local (Connell, pc).
    - San Antonio designs its travel time signs primarily to accommodate local commuters (Fariello, pc).
    - Missouri designs its travel time signs primarily to accommodate local commuters (Sommerhauser, pc).
    - A statewide survey in Florida found that drivers aged 18-49 were most likely to drive during rush hour while older drivers were most likely to drive midday between rush hours (Executive Board Workshop Briefing Regarding Customer Satisfaction Survey)
2. What are the best practices to accommodate drivers who are *familiar* with an area (e.g., residents, commuters) versus those who are *unfamiliar* with an area (e.g., tourists, business visitors)?
    - Drivers who are familiar with an area have higher expectations for information accuracy than unfamiliar drivers (Campbell et al., 1998).
    - FHWA suggests that travel time signs might display distance to destinations rather than, or in addition to, destination name because drivers unfamiliar with an area might not know how to interpret a travel time to a destination of unknown distance (Meehan, 2005a). Travel time CMS in Atlanta, Nashville, Missouri, and Baton Rouge include distance to destination.
    - Orlando showed delay time rather than travel time until June, 2007 when they changed software providers. The switch to travel time was made to ensure consistency with Florida's 511 practices and to comply with the federal grant that provides funding for the travel time system (Heller, pc).
    - Wisconsin recommends targeting messages to commuters during rush hours and to general traffic during other hours. Wisconsin emphasizes use of landmarks (e.g., downtown, stadium) as travel time destinations during rush hours. Outside of rush hour, Wisconsin primarily uses destinations that are used on static signs or that are easily located on maps. For example, freeway interchanges should be identified by cross street identifier rather than interchange name (e.g., Zoo) for general traffic, or distances should be used rather than landmarks (Wisconsin Department of Transportation, 2006).
    - San Antonio often uses interstates as destinations because they are useful and relatively familiar landmarks for all drivers, familiar and unfamiliar (Strain, 2005).
    - Idaho plans to use common names for destinations (e.g., Boise Airport, City Center) that will be meaningful to drivers unfamiliar with the area (Koeberlein, pc).
    - Delay time can be good for familiar drivers like commuters, but others will have little sense of what it means (Dembowski, pc).
    - Utah's current system is only especially useful to drivers with a high degree of local knowledge, but the upgraded system will add distance to destination to CMS and use landmarks in place of some road names (especially for distance destinations) (Clayton, pc).

- Although Missouri considers local drivers and commuters to be the primary audience for travel times, distance to destination was added to CMS as a compromise to accommodate drivers unfamiliar with the area (Sommerhauser, pc).

3. What are the particular information needs and preferences of commercial vehicle drivers and emergency vehicle drivers?
    - Commercial drivers often work on tight schedules and may find travel time especially useful to plan around delays (Clayton, pc).

Driver Assumptions about Travel Time System

4. How do drivers believe that travel time is calculated and how does this affect their trust and behavior? How precise do they expect travel time estimates to be?
    - A lab study found that people inherently understand that travel time is an estimate and the time on the board doesn't represent a precise prediction; however, drivers can use their knowledge of local traffic patterns to predict how travel time has changed since the last measurement, so the authors recommend adding time of most recent measurement (Dudek, Trout, et al., 2000). Only Houston appears to include time of most recent measurement on travel time CMS.
5. Do drivers attribute erroneous travel time reports to outdated data, generally poor system functionality, or an occasional system failure?
    -
6. How do drivers interpret the presence of non-travel time message on CMS that normally displays travel time? Do drivers understand that travel time is the default message and that other messages are considered higher priority? Do drivers understand that (in most jurisdictions) travel time is only displayed during certain hours of the day?
    -
7. How do drivers use travel time CMS in conjunction with other traffic information sources (e.g., radio traffic reports, 511, pre-trip information)?
    - In the Bay Area, the travel time data used for CMS display is also the basis for 511 travel time reporting, private traffic reporting companies, and news organizations. The consistency between various sources reinforces the validity of the information (Lively, pc).

Perceived Value of Travel Time Information

8. How does the public feel about travel time information?
    - In San Antonio, people initially considered travel time a nice-to-have feature, but now that it's been implemented people view it as a necessity (Strain, 2005).
    - According to a survey conducted in the United Kingdom, people who liked travel time information did so mostly because it keeps them informed; relatively few thought that it minimizes delays, gives advance warning of conditions ahead, or allows better trip/route planning. Of the few (12%) who didn't like travel time or were uncertain, it was mainly because they believed the information was inaccurate, that the information was irrelevant

because there was no alternative to the route, or that travel time would encourage speeding or driver distraction (Edwards, 2006).

- In a 2004 survey, 82% of Houston respondents had a positive opinion of travel time CMS (Texas Department of Transportation, 2005).
- United Kingdom drivers strongly preferred travel time over general information/safety messages (Edwards, 2006).
- United Kingdom drivers thought both travel time (82%) and delay time (91%) were useful (delay time may have rated higher than travel time because travel time is only used when conditions are normal) (Edwards, 2006).
- Travel time information allows drivers to phone ahead and let others know they'll be late in advance (Hoops & Gallegos, 2006).

9. What outreach can be conducted to increase the value that drivers receive from travel time displays?
    - Public feedback can help to identify popular locations to use as travel time destinations (Meehan, 2005b).
    - Jurisdictions can provide notification of planned travel time displays to the public. For instance, San Antonio posted the message "TRAVEL TIMES ARE COMING IN XX DAYS" on CMS (Meehan, 2005b).
    - Public outreach campaigns can help to mitigate driver confusion and slowing following travel time implementation (Meehan, 2005b).

Message Content / Information Elements

10. What type of information can be provided to drivers regarding traffic conditions?
    - Travel time
    - Average speed of traffic
    - Delay time (time in excess of free-flowing travel time or "normal" travel time)
    - Speed as percentage of free-flowing (e.g., 80%) (Lerner & Llaneras, 2000)
    - Traffic information should be quantitative rather than qualitative (Lerner & Llaneras, 2000).
11. What information do drivers want on CMS?
    - A survey of Houston drivers found that 93% wanted incident reports and 82% wanted travel time. Many drivers though that incident reports were important, but that they need travel time in addition to decide how an incident affects their trips (ITS for Traveler Information).
    - For advanced traveler information systems (ATIS), the most desired/effective information includes incident location, type, and estimated delays associated with incidents, length of backup, suggested alternate routes, and alternate route directions. Traffic maps with incident locations and segment travel times were considered highly desirable (Llaneras et al., 1999; cited in Lerner et al., 2000).
    - Drivers generally want both descriptive information (reason for delay) and temporal information (extent of delay). Descriptive information provides the context for the temporal information (Lerner et al., 1998a).
    - Given the scenario of a traffic incident ahead, the information that most drivers want is the location of the incident and the current delay (Lerner et al., 1998a).

- Drivers generally prefer traffic information in terms of time (travel time, delay time) rather than traffic speed (Lerner et al., 1998a).
- Drivers prefer quantitative descriptions of delay rather than qualitative descriptions (Lerner et al., 1998b).
- In a survey, nearly 75% of drivers in the United Kingdom suggested improvements to existing travel time signs. These included (in rank order): information about the reason for delay*, alternate route information, improved accuracy/timeliness of information, improved CMS locations, add more CMS, and include travel speed (Edwards, 2006). *If delay is incident/roadwork related, it is more likely that there is a distinct endpoint to the delay than if delay is just congestion-related.
- A survey of in-vehicle travel time information recipients found that drivers most wanted the exact location of congestion. Following this, backup length, lane closure information, type of problem, and average speed through the area were rated similarly (Minnesota Department of Transportation, 1998).
- An online survey of drivers in response to a work zone speed advisory system (which provided the average speed of traffic through the work zone) found that 51% of drivers wanted CMS to display average speed while 69% wanted CMS to display delay time (Pesti et al., n.d.)

12. What information do transportation agencies include on travel time CMS?
    - In California, delay time was considered good for drivers familiar with an area, but not for unfamiliar drivers who might not know how to interpret it. Travel time was used instead because many areas of California have a significant amount of non local traffic (Jenkinson, pc).
    - Forth Worth specifically uses travel times to major intersections (rather than landmarks or distances) because 90% of the traffic that could use the signs is local traffic (Connell, pc).
    - In San Antonio, distance to destination is not included because there is not enough room on CMS (Fariello, pc).
    - The Transportation Service Center manager for Illinois Department of Transportation believes that drivers' use of travel time CMS varies widely and that it is more meaningful to drivers than congestion information (Galas, pc).
    - A lead ITS engineer for Texas Department of Transportation believes that commuters who drive a route daily develop travel time expectations and can calculate their own delay time based on the difference from normal CMS travel time. Therefore, travel time provides more useful information to commuters than delay time (Fariello, pc).
    - Utah is considering adding distance to destination to travel time CMS because travel times don't mean much unless drivers have a good sense of how far away the destinations are (Clayton, pc).
    - When Utah upgrades its travel time system, distant destinations will be more general and well-known (e.g., Salt Lake City), whereas closer destinations will be more specific, such as landmarks or road names. Although Utah currently only uses road names as destinations, Clayton believes that road names are too specific to mean much to drivers who are a long distance away, and may not have a sense of how far they are from the road. (Clayton, pc).
    - Orlando includes travel time, distance, and destination name on CMS. This limits CMS to showing one destination per phase, so two phases are used to show second a second destination (Heller, pc).

- Missouri primarily uses street names that are also listed as exits on static signage as destinations. "Downtown" is used as a destination because it applies to a broad section of drivers whereas relatively few drivers may be familiar with specific exits on the city's Interstate loop. Some drivers have complained that downtown is too vague and they are unsure where downtown begins (Sommerhauser, pc).
- Missouri shows distance to destination because drivers can easily compare distance versus travel time to determine how well traffic is moving (Sommerhauser, pc).
- Missouri opted not to show delay time because they considered it to be confusing to drivers. Travel time is more concrete and meaningful to drivers and implies greater accuracy of calculations (Sommerhauser, pc).

13. Should travel time information be descriptive and/or prescriptive?
    - Descriptive (i.e., state the conditions) is more neutral because it makes no judgment and suggests no action) and allows drivers to interpret the information themselves. Prescriptive (i.e., suggest an action) may require a higher threshold of accuracy (e.g., if you tell people what to do, you'd better be confident that it's the best option). Prescriptive information may have greater influence on driver behavior, which could be positive in the viewpoint of traffic management centers (Lappin & Bottom, 2001).
    - Prescriptive information (e.g., suggested rerouting) is more likely to be used by people knowledgeable about area roads (Lappin & Bottom, 2001).
    - Driver compliance is highest for messages that combine information with prescription, followed by information only, and finally prescription only (Lappin & Bottom, 2001).
    - Drivers generally preferred descriptive information (men in particular) on an in-vehicle ATIS, but might be more willing to use route guidance and rerouting information if they had more control over type of routing (e.g., use favored alternates, use local streets) (Mehndiratta et al., 1999).
14. If a destination road has multiple names (e.g., name and number), how should it be identified on CMS? What about destinations with names too long for CMS? For numbered roads, are the letters necessary (e.g., I-95 vs. 95, SR-76 vs. 76)? Should road names include their "surname" (e.g., RD, AVE, BLVD)?
    - In practice, agencies tend to use major numbered highways and interstates as destinations on CMS. Minor roads, boulevards, etc., tend not to be used. For major roads, the standard abbreviated highway designator is included in the name. Space is rarely an issue because numbered roads occupy 3 characters at most. If space is limited, names are sometimes abbreviated (e.g., DWNTWN instead of downtown, ATL instead of Atlanta).
    - Lab study found that route number prefix (e.g., **RTE** 28, **I-**95) should be included on sign because only 75% of people correctly identify number alone as route number (17% think it's the exit number). This problem might be greatest among drivers who are unfamiliar with the area (Dudek, Trout, et al., 2000).
15. If delay time is reported rather than travel time, how should "normal" travel time be defined to estimate delay time? How slow must traffic be to be considered delayed?
    - Delay time is harder for drivers to "disprove" than travel time, so delay time may be advantageous in maintaining system credibility if time algorithms are error-prone (Neudorff et al., 2003). Utah originally showed delay time for this reason, but switched to travel time when data quality was improved.
16. If average speed or travel time reflects traffic in excess of speed limit, what information should be provided?

- Bay Area established a minimum travel time, which is the lowest travel time that the sign will display, regardless of actual traffic speed. This is defined as the time taken to drive the segment at the posted speed limit. A maximum travel time is also shown; it is equivalent to 10 times the minimum travel time or 99 minutes, whichever is less. If the measured travel time exceeds the programmed maximum, the line on the CMS is blanked out (though Margulici, 2006 suggests that excessive travel time will be displayed as OVER XX MIN). Implementers plan to select more realistic maximum travel times when more drive time data is available (Caltrans, 2005b).
- Chicago sets its minimum travel time for a route to the time it would take to drive the route at the speed limit (Webb, 2004).

17. How should travel time destinations be defined?
    - Destinations can be exit names (best for locals) or exit numbers (best for out-of-towners) (Lerner & Llaneras, 2000).
    - Landmarks (e.g., downtown) can be useful as destinations because they are understandable to both familiar and unfamiliar drivers, and they also often are vague destinations that support the idea that travel times are only estimates (Margulici et al., 2006).
    - Washington state tends to use town names rather than specific interchanges because these destinations are more general and allow for some imprecision in travel time calculation (Jacobson, pc).
    - San Antonio was unsure what to call a complicated interchange and ended up creating a new name for the destination (410 South Cutoff). Drivers began to associate the name with the interchange and news agencies began to use the name in their reports (Fariello, pc).
    - Chicago uses either major intersections or well-known landmarks as destinations. The choice of which type to use depends on which is best known to commuters. In the case of Chicago, landmarks must be more specific than "downtown" because downtown is 7 miles long, which is too broad to be used as a destination identifier. Destinations were selected by Illinois Department of Transportation without public input, but Illinois Department of Transportation considers public feedback with regard to destination names. However, the travel time system is old and difficult to change (Galas, pc).
    - CA rejected adding distance to destination to travel time signs because it seemed to be too much information (Lively, pc).
    - Portland recommends selecting destinations that are known to a majority of drivers (Oregon Department of Transportation, 2005).
    - Orlando primarily uses road names that are major exits from the freeway, but occasionally uses major landmarks such as a bridge (Heller, pc).
    - Wisconsin recommends that freeways be called by their numerical designation rather than local name, though there can be exceptions where name is more familiar (Wisconsin Department of Transportation, 2006). Destinations should be identified by crossroad because this is consistent with static signage and allows drivers to cross reference information between CMS and static signage (Dembowski, pc).
    - Wisconsin specifies that CMS should not use landmarks such as DOWNTOWN or AIRPORT (Wisconsin Department of Transportation, 2006), though this may be done infrequently when landmark or interchange name is more meaningful to drivers than official designations (Dembowski, pc).

- Wisconsin changes its destinations on travel time signs depending on time of day. CMS show destinations relevant to commuters during rush hours and more general destinations for a broader audience outside of rush hours (Meehan, 2005a; Dembowski, pc).
- California must be careful about which exits are selected as destinations, especially when travel times are shown for long distances between towns/cities, to avoid political ramifications of which towns get named and which do not. This is a good reason not to provide travel times over very long ranges on CMS, though 511 and web sites can be used for this purpose (Lively, pc).

18. How can travel time information be provided between two locations if the start point is *not* at the location of the travel time CMS?
    -
19. If delays begin somewhere between the CMS and a destination, how can drivers be made aware of where delays begin? A similar information need may exist if delays end before the destination reported on the CMS.
    - A two phase message may be used to display both travel time and congestion information. This is done in a few jurisdictions, including San Antonio (see photo below, from Strain, 2005):
    - 

    - Graphical route CMS allow drivers to see travel times or congestion levels for multiple segments of the roadway and can determine where congestion or delays exist (see Question 43 for examples).
    - Delay time (rather than travel time) CMS might be advantageous because they can report the delay between any two points (e.g., Edwards, 2006).
20. Is there a way to inform the driver whether delays are improving or worsening? What value would this have?
    - A few traffic web sites provide this information, but no CMS do in the U.S.
    - Drivers who are familiar with traffic patterns in an area (e.g., commuters) may have a sense of how traffic patterns develop over time. For example, congestion may tend to worsen early in the morning commute (e.g., 7 am to 8 am) and then improve late in the morning commute (e.g., 9 am to 10 am). Drivers familiar with these patterns may expect their actual drive time to be somewhat better or worse than reported conditions.
21. How much information can be presented on a travel time CMS before driver and system performance begin to suffer?
    - In a Bay Area survey, 84% of respondents said three destinations on a trael time CMS does not provide too much information, despite Caltrans concerns to the contrary (Bay Area was using some three-destination signs at the time of the survey) (Margulici, 2006).

Message Design and Layout

22. How should messages be constructed?
    - It is important to standardize order of words, order of message information units, and application of messages (Neudorff et al., 2003).

- FHWA recommends no qualifiers on travel time (e.g., approximately, estimated) because drivers understand that it's not exact (Meehan, 2005a).
- FHWA recommends using general destination information (e.g., downtown) rather than specific exits for travel time CMS where the destination is more than 10 miles away (Meehan, 2005a).
- Wisconsin recommends that all traveler information messages be limited to 8 words (Wisconsin Department of Transportation, 2006).
- Wisconsin uses all caps, with only one font and one font size (Wisconsin Department of Transportation, 2006).
- Wisconsin recommends proportional spacing rather than fixed spacing where possible (Wisconsin Department of Transportation, 2006).
- Wisconsin recommends justified format for travel time, but centered is used for all other information (Wisconsin Department of Transportation, 2006).
- Portland appears to list destinations in reverse order (farthest destination is on top line of CMS), but it is unclear if this is standard practice (Oregon Department of Transportation, 2005).

23. Is a sign header necessary (e.g., TRAVEL TIME TO:)? What should be used as a header?
    - Kansas City (KC Scout) determined that header information was not necessary because people recognize travel time signs and eliminating header info frees up significant space that can be used for message content (Webb, 2004). Baton Rouge and Nashville also do not use headers.
    - Utah plans to eliminate "travel time" header because it does not help drivers and replace it with distance to destination when the system is overhauled soon (Clayton, pc).
    - FHWA says that header text such as "Travel time to:" is good but not necessary because people understand the message when only destination and travel time are provided (Meehan, 2005a).
    - California conducted focus group testing to determine the best header text. The public wanted full sentences, but final text was a compromise due to limited space (Jenkinson, pc).
    - Caltrans District 8 (Inland Empire) uses "MINUTES TO" as a header (http://www.dot.ca.gov/dist8/tmc/webmap.htm)
    - Chicago uses "TRAVEL TIMES TO" as a header when there are 2 destinations, but excludes headers when there are 3 destinations (Illinois Department of Transportation, 2005).
24. What are the best practices for abbreviations? How do they affect driver comprehension?
    - San Antonio did not test abbreviations with the public, but drivers figured out what they meant (Fariello, pc).
    - Durkop & Dudek (2003) investigated driver comprehension of abbreviations on CMS. Although most abbreviations were not directly relevant to CMS, percentages of participants who correctly comprehended abbreviations ranged from about 80% to nearly 100%.
25. How should messages be formatted / laid out?
    - The Manual on Uniform Traffic Control Devices (MUTCD) (Federal Highway Administration, 2003) states that:
        - "Changeable message signs should be capital letters and have a desirable letter size of 450 mm (18 in) or a minimum letter size of 265 mm (10.6 in). Signs

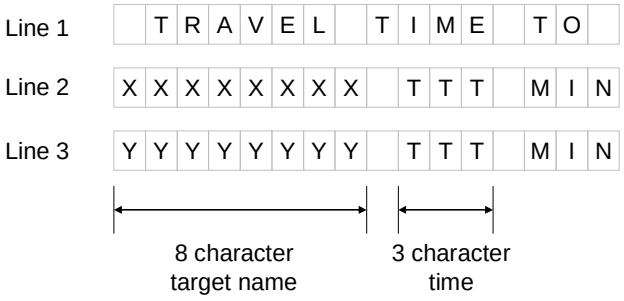
should be limited to not more than 3 lines with not more than 20 characters per line."

§

- Table reproduced from report by Enterprise (2004, p 34-35):

State	Display Details
Arizona	18" Character Height, 3 lines
California	Full Matrix,12" to 60" Character Height (18" during typical operation)
Georgia	18" Character Height, 1000' Minimum visibility
Iowa	Full Matrix, 18" Character Height
Missouri	18" Character Height
Nebraska	1100' Minimum Visibility
New Mexico	Full Matrix, 12" Character Height
North Carolina	18" Character Height
Ohio	12" or 18" Character Height, Capital Letters Only
Oregon	18" Character Height
Pennsylvania	10 ½" Character Height (Absolute Minimum), 18" Character Height (Typical)
Utah	Full Matrix, 12" Character Height on Surface Street VMS, 18" Character Height on Freeway VMS
Virginia	Full Matrix, 18" Character Height, 3 Lines, 21 Characters per Line
Washington	18" Character Height

- San Antonio's CMSs are primarily 3x18 character matrixes.
- Wisconsin's CMSs are 3x21.
- Kansas City's are 3x21 (Webb, 2004).
- Caltrans has minimum spec of 3x16, formatted as shown below (Caltrans, n.d.):



2 Target Example

	T	R	A	V	E	L		T	I	M	E		T	O	
B	E	A	C	H		B	L			1	1		M	I	N
2	2		F	W	Y					1	9		M	I	N

1 Target Example

	T	R	A	V	E	L		T	I	M	E		T	O	
L	A	X								2	0		M	I	N

- Travel time sign in Los Angeles County (photo courtesy of Jeff Aragaki)
- 

- Travel time sign in Ventura County, CA (Caltrans District 7) (Hoops & Gallegos, 2006):
- 
- Nashville travel time sign (top) and replica (bottom) (Tennessee Department of Transportation, 2005):

- 

- 

- Atlanta travel time format (ITS Engineers, 2004):

				I	-	2	0	/	E	X	I	T		2	4	7				
					1	0		M	I		A	H	E	A	D				
T	R	A	V	E	L		T	I	M	E	:		1	2	-	1	4		M	I	N

- Atlanta travel time sign (Meehan & Rupert, 2004):
- 

- Atlanta travel time sign replicas (not in true color) (Rupert, 2005):

o 

o 

o

o Baton Rouge travel time sign (Louisiana Department of Transportation and Development, 2007):

o 

o Portland travel time sign format (Oregon Department of Transportation, 2005):

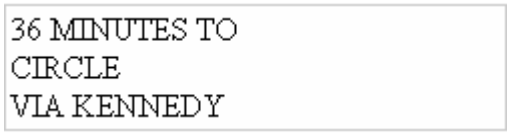
o

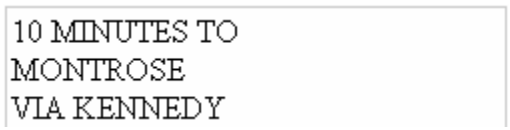
TRAVEL TIME TO	
I-405	12-15 MIN
HWY 26	10-12 MIN

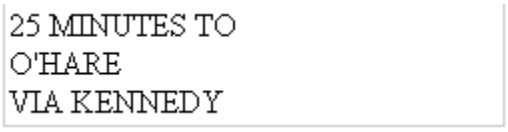
o Seattle area travel time sign:

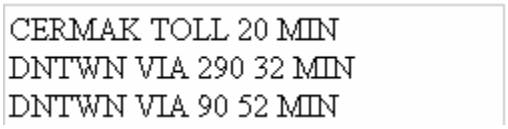
o 

- Chicago area uses a variety of formats for travel time signs, including two-phase signs (see last two examples). The images from gcmtravel.com below reflect content, but not actual layout:
- 

- 

- Phase 1:
- 

- Phase 2:
- 

- Phase 1:
- 

- Phase 2:
- 

- Bay Area travel time signs (Margulici, 2006). The top photo shows proper procedure; it's unclear why the bottom photo shows destinations in reverse order:

- 

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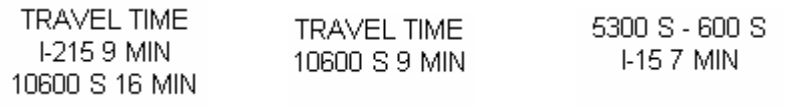
- Formatting examples of Bay Area's three travel time sign configurations. Two-destination (left) is most common. Three-destination replaces the banner text with the nearest destination (center). One-destination (right) may have one or two phases (two-stage is shown) and may be on smaller arterial CMS which necessitate shorter messages (Travel times on changeable message signs in District 4: Field elements and system configuration, 2006):
TRAVEL TIME TO	
RTE 92	XX MIN
SFO ARPT	XX MIN

SF DWNTWN	XX MIN
SFO ARPT	XX MIN
OAK ARPT	XX MIN

TIME TO RTE 92 XXX MIN
TIME TO RTE 280 XXX MIN
- Utah travel time sign replica:
- 

- Examples of unformatted Utah travel time text (http://www.utahcommuterlink.com/):

- 

- Utah previously used delay time rather than travel time because of a lack of confidence in travel time data. The display format was like this (Webb, 2004):
- 

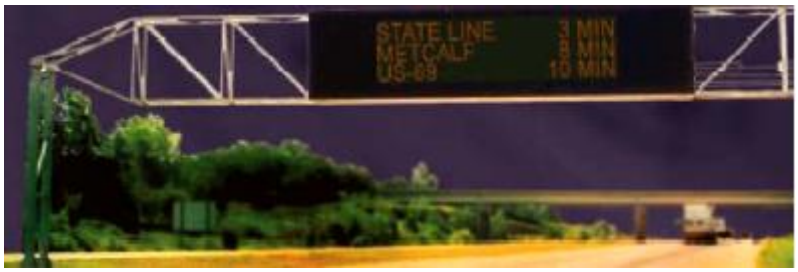
- San Antonio travel time sign (top) and replica of a two-phase travel time message (bottom) (Strain, 2005):
- 

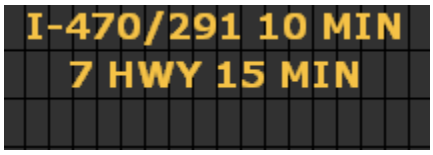
- 

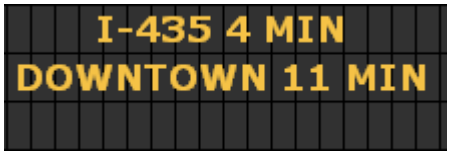
- Although most travel time CMS in San Antonio report short travel times as UNDER 5 MINS, a sign observed on June 6, 2007 appeared like this, possibly because there was not enough space for UNDER 5 MINS (http://www.transguide.dot.state.tx.us/TravelTimes/signs.php):
- 

- In Houston, travel time signs include time of most recent reading (see replica below) because probe data can result in latency of up to about 10 minutes (this way drivers know how outdated the info might be) (Texas Department of Transportation, 2005):
- 

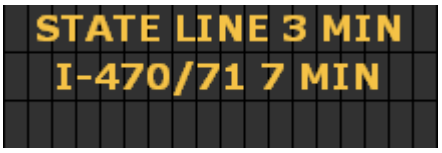
- Kansas City, MO travel time signs showing single-destination sign (top) and three-destination sign (bottom) (KC Scout web site):
- 

- 

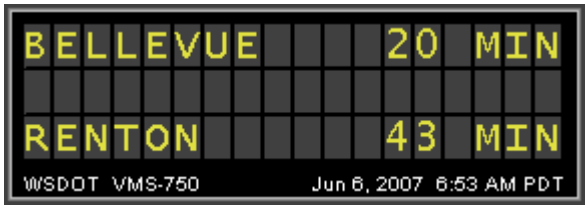
- Electronic replicas of Kansas City travel time signs (KC Scout web site):
- 

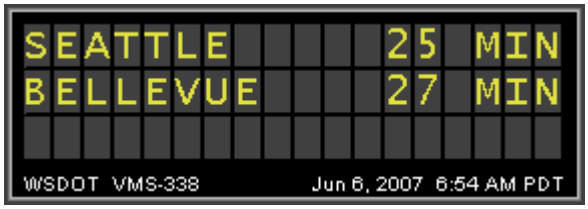


- 



- Wisconsin travel time sign (Langer, 2005):
- 

- Seattle area travel time sign replicas (http://www.wsdot.wa.gov/traffic/seattle/vms/):
- 

- 

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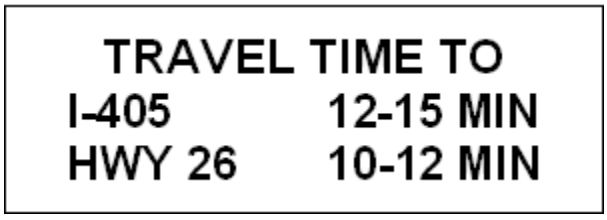
- A portable work zone system used on I-95 in NC provided three levels of message: general message (no delay), minor delay, and major delay (which was phased as follows: TRAFFIC STOPPED AHEAD / 20 MINUTE DELAY / USE EXIT 141 AS ALT) (Bushman & Berthelot, 2005).
- CMS in the United Kingdom use travel time when conditions are normal and delay time when there is a major incident (see example replicas below) (Edwards, 2006):
- 

- 

- United Kingdom journey time "link" sign to provide travel time on a road other than the current one (Highways Agency, 2003):
- 

26. If travel times to multiple locations are presented, how should travel times be ordered?
    - Most show nearest destination on top, but Chicago appears to order destinations both ways (see below) (Illinois Department of Transportation, 2005):
    - 

- Travel time CMS in Portland also appear to place the farthest destination on top (Oregon Department of Transportation, 2005):
- 

Travel Time Reporting

27. How should travel times be shown?
    - FHWA recommends time range of 2-3 minutes (Meehan, 2005a).
    - Tennessee uses 2-3 minute range (Texas Department of Transportation, 2005).
    - Atlanta uses a 3 minute range for most destinations, but may use a 2 minute range for especially short trips or a 4 minute range for especially long trips. The purpose of showing a range rather than an exact number is to help ensure that the estimate is accurate for most drivers (Meehan, 2005b).
    - Wisconsin Department of Transportation rounds up to the nearest minute (Langer, 2005).
    - Kansas City rounds up to nearest minute (KC Scout website). Webb (2004) reports that the initial plan was to round to the nearest minute as the low range estimate, then add 20% as the high range estimate. It's unclear whether this was ever done.
    - San Antonio shows a range of 3 minutes so that people understand that travel time is not exact, but their own time will usually be within the range. The actual calculated time is rounded down to the nearest minute to establish the bottom of the range, and two minutes are added to establish the top of the range (e.g., 5.5 min calculated time will show as 5-7 min).
    - Orlando rounds up to the nearest minute, but travel time CMS on a privately owned toll road in Orlando show a range of minutes. Florida Department of Transportation and the private company do not coordinate travel time reporting procedures (Heller, pc).
    - Caltrans has a scaled estimation regime: recommends rounding up to the nearest X minutes, where X may be progressively larger as travel time increases (e.g., 17 minutes rounds to nearest 5 minutes (i.e., 20 min); 44 min rounds to nearest 10 minutes (e.g., 50 min) (Caltrans, n.d.).
    - California displays a time range because travel times are based on data from prior vehicles and is therefore outdated rather than predictive (Jenkinson, pc).
    - Oregon Department of Transportation presents travel times in range of +/- 1 minute during most times, but uses a range of up to 4 minutes (+/- 2 minutes) for periods of congestion. This is because travel time is less predictable during congestion (Oregon Department of Transportation, 2005).
    - In Wausau, Wisconsin, a portable CMS displays real-time traffic speed through rural work zone (Vik, pc). Measurement is imprecise and reported speeds are rounded to nearest 10 mph (e.g., 55, 45, 35) or stopped traffic ahead. Purpose is not to indicate travel time so much as to warn drivers to expect slowing or stopped traffic (Dembowski, pc).

- Travel time information should be supplemented with an indication of travel time variability or typical range (Lerner & Llaneras, 2000).
- Washington rounds to the nearest minute. Even though measurement is not precise to that level of accuracy, the public accepts it (Jacobson, pc).

28. What information can be provided to let drivers know whether current travel times are good or bad (or better or worse than usual)?
    - Signs could report average travel time (or speed), but this information is probably excessive on roadways (Lerner & Llaneras, 2000). In fact, Caltrans considered showing average or normal travel times on roadside static signage, but opted not to do this (Lively, pc).
    - Milwaukee's online travel time site shows actual travel time and time in excess of normal drive (i.e., delay time). Routes where travel time is at least 20% greater than normal are shown in bold.
29. If traffic is free-flowing for all sign destinations, would a "no delays" type of message have more meaning to drivers than travel time?
    -
30. If travel time is fairly consistent from day to day, or if travel times are presented at times when congestion very rarely occurs, will drivers begin to tune out travel time messages? If so, what can be done to draw attention when conditions differ from the norm?
    - In Wisconsin, where travel times are displayed 24/7, Department of Transportation staff believe that drivers become familiar with travel time signs and can tell with a very quick glance if the travel times differ from normal (Dembowski, pc).
    - In Forth Worth, travel time implementer believes that that once drivers are familiar with travel times, they only look at numbers, not text (Connell, pc).
    - Some drivers in Utah have complained that they begin to tune out travel time signs because they show the same information all the time, so when important information is presented, they tune it out as well (Clayton, pc).
31. How often should travel time estimates be updated?
    - Wisconsin Department of Transportation updates every 60 seconds because it's a reasonable time for viewers to see updates and during congested times, travel times are highly variable (Langer, 2005).
    - Caltrans District 7 updates travel times every 3 minutes, though the system can accommodate spans of 1 to 5 minutes (Caltrans travel time information project summary).
    - Caltrans District 4 proposed (as of Feb 2005) that the system update travel time when any one route's predicted time is at least 2 minutes different than the calculated time, or consistently off by 1 minute for 3 consecutive minutes. Updates are made every 15 minutes no matter what other conditions exist. Also, if data are unavailable for 10 minutes, the destination is blanked out from the CMS (Margulici et al., 2006).
    - Houston updates travel times every 10 minutes; a few locations are updated more frequently. Houston's best practices say that travel time information should not be older than 15 minutes, though most jurisdictions update travel times much more frequently (Texas Department of Tranportation, 2005).
    - Utah updates travel times every minute (Utah Commuterlink website).

CMS Locations and Destinations for Travel Time Display

32. What road segments should travel times be displayed for?
    - FHWA recommends reporting for heavily used segments and choosing heavily used exits as destinations (Meehan, 2005a).
    - Oregon Department of Transportation guidelines say that at least 50% of drivers who see a travel time CMS should reach the destination shown on the CMS. In other words, CMS shouldn't show a destination that most driver will exit prior to (unless diverting due to congestion) (Oregon Department of Transportation, 2005).
    - Oregon Department of Transportation guidelines say that travel time destinations should be "well known to a majority of drivers" (Oregon Department of Transportation, 2005).
33. What are appropriate maximum and minimum segment lengths (in miles or travel times) for travel time reporting?
    - The longer the road segment, the more likely it is that that travel times will be inaccurate. However, longer travel times may be acceptable if there is a long distance between exits, if the majority of drivers are on the road for a long distance, if the road is not prone to major delays, and if the travel time calculation is relatively precise or predictive (Lively, pc).
    - San Antonio posts travel times below 5 min as "UNDER 5 MINS" and over 30 min as "OVER 30 MINS" because travel times over 30 minutes are too great to be accurate (Fariello, pc).
    - In the Atlanta area, travel times over 30 minutes are displayed as "30+ MINUTES" (Meehan, 2005b).
    - Bay Area tries to keep destinations between 4 and 20 miles from travel time sign because more than 20 miles is too hard to predict and less than 4 doesn't provide useful information to most drivers. A rule of thumb is that at least 50% of drivers who see a given destination should be going to or beyond the destination (unless congestion causes rerouting) (Margulici, 2006).
    - Utah has some CMS that display travel times as small as 3 minutes, but these provide little value to drivers, especially since distance to destination is not provided (e.g., 3 minutes is very good for a destination 3 miles away, but very poor for a destination 1 mile away) (Clayton, pc).
    - Portland suggests reporting travel time to destinations between 3 and 15 miles from the CMS because travel times are difficult to predict for distances greater than 15 miles (Oregon Department of Transportation, 2005).
    - Wisconsin Department of Transportation aims for travel times between 6 and 20 minutes. 6 minutes is so short that it's hardly worth posting; more than 20 minutes can be inaccurate and drivers can forget what information they saw on a CMS many miles back (Langer, 2005).
    - Oregon Department of Transportation recommends that destinations be 3 to 15 miles beyond the CMS because travel times are too hard to predict for longer distances) (Oregon Department of Transportation, 2005).
    - In the Bay Area, most travel times are for destinations 5 to 15 miles away.
    - In San Antonio, most travel times are for destinations 5 to 10 miles away.

- In the Atlanta area, travel time destinations usually range from 5 to 15 miles away (Meehan, 2005b)

34. How can travel time displays be implemented on special use lanes or separated lanes (e.g., HOV lanes, HOT lanes, local/express lanes)?
    - Chicago calculates travel times for express lanes and local lanes separately. They are displayed on separate CMS (Galas, pc).
    - California does not display travel times for HOT/HOV lanes, but does try to display mainline travel times prior to HOT lane decision points. Some HOT lanes are managed by private companies (Jenkinson, pc).
    - Georgia Department of Transportation provides travel times for HOV lanes (http://www.georgia-navigator.com/about).
    - Seattle reports travel times for mainline and HOV separately on its web site, but not on CMS.
    - California has considered adding travel time CMS for HOV, but is concerned that shorter reported travel times on HOV will lead to increased violations and increased delays. HOV travel times will require coordination with enforcement if it is to be successful (Lively, pc).
    - Forth Worth is considering displaying travel time for HOT lanes, but specific plans are uncertain because HOT lanes will be under different jurisdiction than mainline CMS (Connell, pc).
    - A prototype "lane choice panel" in the United Kingdom using both static and dynamic elements might be one model reporting travel times on separated roads (Highways Agency, 2003):
    - 

Route Choice / Diversion

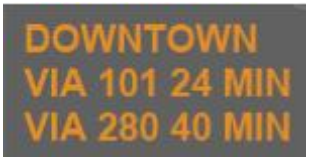
35. What information can be provided about alternate routes or travel times on roads other than the one that drivers are currently on?
    - San Antonio provides occasional travel times to a major destination via two different routes, but does not provide explicit routing guidance. This is because the CMS do not provide enough space and because the target audience for travel time (commuters) will generally know the best alternate routes and can decide for themselves whether they should divert (Fariello, pc).

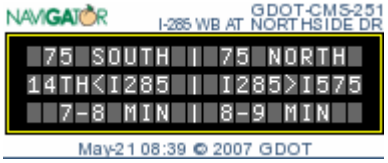
- Wisconsin recommends travel time on alternate routes be displayed like this (Wisconsin Department of Transportation, 2006):

FREEWAY TIME TO AIRPORT	
VIA I-894	15 MIN
VIA I-94	18 MIN

- Houston can show travel time on an alternate route like this (Transtar website):
- 

- Seattle area can show travel time via alternative routes like this (Washington State Department of Transportation travel time web site):
- 

- In the Bay Area, travel time on alternate routes is shown like this (Margulici, 2006):
- 

- Atlanta area has at least one sign that shows travel times on multiple routes, though this sign appears to be designed for two separate audiences (those taking 75 South and those taking 75 North) rather than showing alternative routes for a single audience (Georgia Navigator website):
- 

- Atlanta also has a sign that shows current speeds in different directions of the same road (like the sign shown above, it is designed for two separate directions of travel) (Georgia Navigator website):
- 

- In Barcelona, alternate route travel times are shown like this (Rupert et al., 2003):

- 

- Given the choice between the two, drivers prefer travel time/delay information rather than diversion information. Drivers can make their own routing decisions if they have appropriate information (Lerner & Llaneras, 2000).
- Orlando shows travel time for the current road and an alternative route (toll road, which is privately owned) on separate phases of a CMS and allows drivers to choose their own route based on the information (Heller, pc).

36. What are the best practices for route diversion?
    - Expected trip time should be the primary factor for route selection/diversion (Lerner & Llaneras, 2000).
    - If an alternate route is suggested, most drivers want to know the travel time for that route (Lerner et al., 1998).
    - Potential time savings from diversion must be balanced against the travel time variability, lower functional class, more complex paths (especially for unfamiliar drivers), and potential for diversion to increase delays on alternate route (Lerner & Llaneras, 2000).
    - If diversion is recommended, travel time for the alternate route should be provided (Lerner & Llaneras, 2000).
    - If transportation agency wants to encourage drivers to use an alternate route, a clear time savings should be shown for the alternate route. If minimal diversion is desired, messages should confirm minimal time differences and minimize certainty about the delay on the primary route (Lerner et al., 1998b).
    - If only minimal information can be presented, drivers prefer descriptive information to route suggestions (Lerner et al., 1998b).
    - The language that indicates level of certainty in route recommendations can be manipulated to influence the percentage of drivers who divert (Lerner & Llaneras, 2000).
    - If an incident is responsible for the recommendation to divert, the CMS should specify where the incident is so drivers can return to original route beyond the incident (Lerner & Llaneras, 2000).
    - Ideally, alternate routes should be freeways, have few turns and signals, require minimal navigation, and immediately result in less traffic density (Lerner & Llaneras, 2000).

- For commuters, route diversion should only be recommended if the time savings is at least 20% (Lerner & Llaneras, 2000).
- Chicago recommends that CMS be located upstream of decision points where drivers can divert (Illinois Department of Transportation, 2005).
- Wisconsin 'passively' encourages diversion by locating CMS before choice points, but they are limited in the ability to suggest alternate routes because if alternate routes are under another agency's jurisdiction, the agency may be upset by the manipulation of traffic on its roads and might feel that the freeway agency is impinging on its jurisdiction (Dembowski, pc).
- California locates travel time CMS before major decision points to allow drivers to make informed route choices. Explicit alternate route information practices vary by district and are generally at the discretion of TMC staff. If there are multiple route options, CMS may state "USE ALTERNATE ROUTE." If there is only one acceptable alternative, the CMS will state the route to take (Jenkinson, pc).

37. What factors influence whether drivers choose to divert (e.g., length of delay, cause of delay, trip purpose, peak vs. off-peak hours, personal characteristics/driving style, familiarity with area/alternates, availability of alternate route, expectations of travel time on alternate route, availability of information about alternates, stress/uncertainty caused by diverting, degree of expected time savings required to make diversion worthwhile)?
    - Drivers are much less likely to follow a route recommendation if it requires diverting from their original route (Mahmassani et al., 1998; cited in Lerner et al., 2000).
    - Drivers who are concerned with minimizing travel time uncertainty (such as commuters who do not have flexible work arrival times) are more likely to seek travel time information and reroute if they face delays on the primary route (Abdel-Aty et al., 1997a; cited in Lerner et al., 2000).
    - Commuters who regularly drive different routes to work are not more likely to reroute around a traffic incident than driver who use a constant route (Abdel-Aty et al., 1997a; cited in Lerner et al., 2000).
    - Young, higher income drivers with long commutes are most likely to divert to another route. Females and people concerned with driving through unsafe neighborhoods are least likely to divert (Abdel-Aty et al., 1997a; cited in Lerner et al., 2000).
    - Drivers who receive en-route traffic information are more likely to reroute around delays and then return to the primary route beyond the congested area. Although en-route information may increase diversions, the diversions may be of shorter average length if drivers return to the primary route beyond the congested area (Abdel-Aty et al., 1997a; cited in Lerner et al., 2000).
    - Drivers are interested in minimizing travel time *variability*, not just travel time itself, so drivers may opt take the route with a more predictable travel time even if the alternative is likely to have a shorter travel time, on average (Abdel-Aty et al., 1997b; cited in Lerner et al., 2000).
    - Drivers prefer routes with fewer navigational maneuvers, segments, and traffic signals, even if the preferred route may be slightly longer to drive (Abdel-Aty et al., 1997b; cited in Lerner et al., 2000).
    - In a simulated ATIS, a graphical representation of congestion ahead significantly increased driver propensity to reroute, especially if the congestion began immediately after a convenient rerouting decision point (Mahmassani, H., & Srinivasan, K., 1998; cited in Lerner et al., 2000). This may have implications for graphical travel time/congestion maps posted as freeway signs.

- On average, commuters tolerate arrival at work between 10 minutes early and 5 minutes late. They are more likely to reroute if predicted arrival is more than 5 minutes late (Mahmassani, H., & Srinivasan, K., 1998; cited in Lerner et al., 2000).
- In a study of an ATIS, drivers were more likely to comply with routing advice on a freeway than on an arterial and when the suggested route involves few turns (Chen & Jovanis, 1779; cited in Lerner et al., 2000).
- Positive perceptions of traffic information accuracy has a significant effect on whether drivers choose to comply with route guidance information (Chen & Jovanis, 1779; cited in Lerner et al., 2000).
- Commuters are more likely to reroute if arrival time predictions exceed their preferred arrival time (Mahmassani & Liu, 1997; cited in Lerner et al., 2000).
- Given complete and accurate information in an ATIS, drivers, on average, will generally require a time savings of 22% for the remainder of their trip before they decide to reroute, but the overall time savings must be greater than 4 minutes (Mahmassani, H., & Srinivasan, K., 1998; cited in Lerner et al., 2000).
- Commuters are more apt to reroute to a faster route if they are running late to work than if they are running early (Mahmassani & Liu, 1997; cited in Lerner et al., 2000).
- Travel time information is most likely to be used effectively on roads with high variability of travel time and among drivers familiar with the area (Chorus, Molin, & van Wee, 2007).
- A survey of online travel time information found that 68% of users in Pittsburgh and 86% in Philadelphia who checked travel times online before leaving home changed their routes based on the information. 47% in Pittsburgh and 66% in Philadelphia adjusted the time that they left home based on expected travel time (ITS for Traveler Information).
- A 2004 survey found that 85% of respondents changed route in response to travel time information; 66% felt that this reduced their travel time, 29% were unsure (Texas Department of Transportation, 2005).
- A survey in the Los Angeles area found that drivers generally would not divert based on travel time info, but like to have the information (Caltrans, n.d.).
- A survey found that 15% of drivers who received travel time information rerouted (the summary does not clarify whether this is for a given trip or in driver's entire experience) (Caltrans, 2005a).
- A lab study in the Netherlands found that drivers prefer routes with predictable travel times over routes with unpredictable travel times, even if the predictable route has a slightly longer travel time, on average. Drivers will reuse a route that took unusually long the day before if the travel time prediction was accurate, but will pick a different route if the travel time prediction was inaccurate (Bogers et al., 2006).

Phasing / Staggering of Travel Time Information

38. Can travel time messages and other messages be shown in multiple phases?
    - Section 2E.21 of the MUTCD (Federal Highway Administration, 2003) states that:
        - "No more than two displays should be used within any message cycle."
        - "Each display should convey a single thought."

        - § "The entire message cycle should be readable at least twice by drivers traveling at the posted speed, the off-peak 85th-percentile speed, or the operating speed."
    - Orlando always shows two-phase travel time messages (one destination per phase). Anecdotal reports do not suggest that the signs are causing distraction or slowing (Heller, pc).
    - Missouri strongly prefers single-phase messages because two-phase messages were reportedly causing traffic to slow on freeways (Webb, 2004). However, Missouri has begun using two-phase messages to alternate incident information and travel time. Two-phase CMS have received positive anecdotal feedback. Traffic had slowed when the signs went into use, but a public information campaign returned the flow to normal. The destination shown for an incident message is usually selected in order to give drivers an accurate idea of where the delay will end and what the travel time will be to the destination. Travel time and incident information support one another and help give drivers a complete picture of the situation and its effects (Sommerhauser, pc).
    - Houston uses single-phase messages because survey results indicate that's what drivers prefer, though they occasionally use two-phase messages if there is important information that can only be conveyed in that format (Texas Department of Transportation, 2005).
    - Idaho plans to show messages in just one stage because two-stage messages have caused slowdowns in the past (Koeberlein, pc).
    - Wisconsin has not experienced traffic problems or distraction as a result of 2-phase messages. It's important to put CMS in location where driver cognitive demand is low and it is visible for a long distance. When people get accustomed to seeing info on a sign, it interferes with them less – they can pull the information they need more quickly and have expectations about sign contents.
    - The "TRAVEL TIME TO" banner can remain and the destinations can be phased to show additional destinations, but this is uncommon in practice. Although his findings are not directly relevant to travel time information, Dudek (2005) found that alternating one line of a three-line CMS did not adversely affect message recall, but did significantly increase reading time.
    - Oregon Department of Transportation only uses single phase messages to minimize driver distraction (Oregon Department of Transportation, 2005).
    - San Antonio sometimes alternates travel time and incident/congestion messages (Strain, 2005):

    - Wisconsin also sometimes alternates travel time and incident/congestion messages.

39. Can CMS be located longitudinally to present relatively large amounts of information (whether related to each another or independent) without overloading drivers (e.g., travel time information on first CMS, rerouting information on next)?
    -

Use of Color, Graphics, Symbols, and Dynamic Elements

40. How can color be used on travel time displays?

- The Manual on Uniform Traffic Control Devices (MUTCD) states that CMS… "that display a warning or regulatory message may use a black background with a white, yellow, orange, red, or fluorescent yellow-green legend as appropriate, except where specifically restricted…." (Federal Highway Administration, 2003)
- Wisconsin forbids use of color (Wisconsin Department of Transportation, 2006).
- A series of studies in the Netherlands on full color information panel signs found that color intensity is not a good way to indicate flow or a preferred route. Colors should always be functional (i.e., only use color to represent meaningful information). Red should only be used to represent blocked roads (note: this is inconsistent with broad practice in the U.S., where red often represents heavy congestion) (Roskam et al., 2002).
- For ATIS, road segments should be color coded green, yellow, and red to represent mean speed of traffic flow. No more than three levels of traffic should be coded. A fourth level for stop-and-go or blocked lanes may be added if necessary (Campbell et al, 1998).
- Drivers make an intuitive connection between traffic light colors and green/yellow/red traffic coding (Miller et al., 1994; cited in Campbell et al., 1998).
- There is no conflict in using red (which typically represents danger) as a color code for slow traffic in ATIS because slowing traffic may constitute a dangerous situation (Ross et al., 1996; cited in Campbell et al., 1998).

41. How can animation be used on travel time displays?
    - The MUTCD (Federal Highway Administration, 2003) states that:
        - "The display format *shall not* include animation, rapid flashing, or other dynamic elements that are characteristic of sports scoreboards or advertising displays."
        - "Techniques of message display such as fading, exploding, dissolving, or moving messages shall not be used."
    - Wisconsin forbids use of animation on CMS (Wisconsin Department of Transportation, 2006).
42. How can symbols be used on travel time displays?
    - In Japan, incidents are identified on graphical CMS using a red 'X' (Lerner et al., 2004):
    - 

    - Japan also uses a different symbol for congestion, as seen at the left of the CMS below (Highways Agency, 2003):

- 

43. Can graphical/map signs be used in place of text-only signs?
    - VicRoads' Travel Time System (Victoria, Australia) shows travel time to destinations (bottom-to-top) and color codes traffic for each leg as green (light), yellow (medium), or red (heavy) (see below). Other signs are posted on arterials prior to freeways and code traffic to major destinations (e.g., downtown) using color coded text stating light, medium, or heavy. A survey found 70-90% public acceptance and 57% of respondents reported that, based on color coding, the traffic they encountered was as expected, with about even numbers reporting it to be more and less than expected (Lerner et al., 2004).
    - 

    - Dutch/German project at AVV Transport Research Centre in Delft developed prototype full color information panels (FCIP) for freeway directional guidance within TRAVELGUIDE Project (see below) (Lerner et al., 2004).
    - 

    - Another sign from AVV (Lerner et al., 2004):

- 

- In Japan, a travel time CMS (top) and an incident/congestion graphical CMS showing alternate routes (bottom) (Lerner et al., 2004):
- 

- 

- Japanese GRIP (left) and congestion information panel (right) (Highways Agency, 2003):

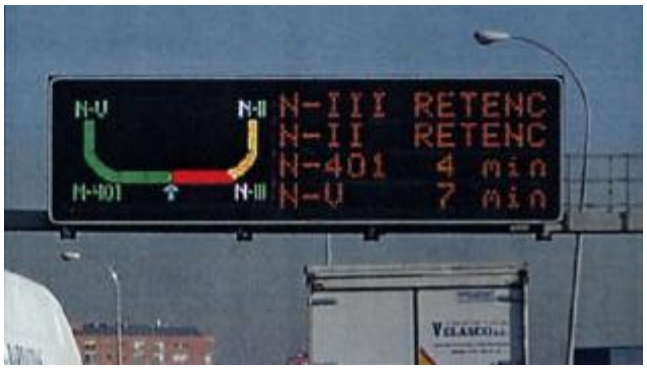
- 
  

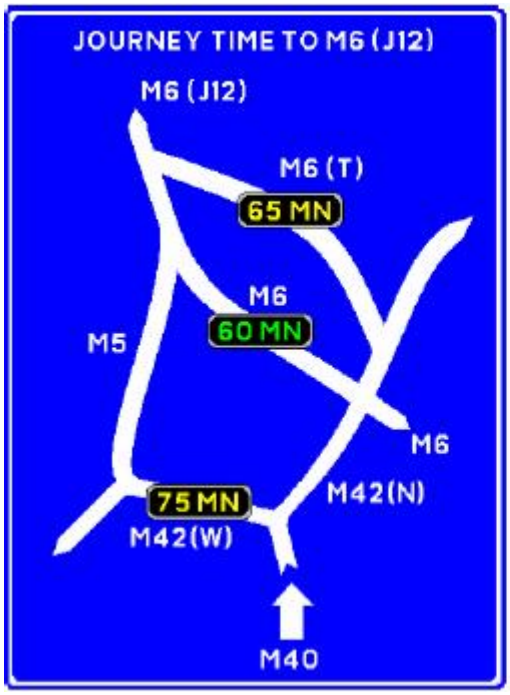
- German GRIP that began operating in Munich area in 2003, with dimensions shown (Highways Agency, 2003):
  

'X ' height	210 mm
Sign Face Width	8000 mm
Sign Face Height	6200 mm
Route Width	240 mm

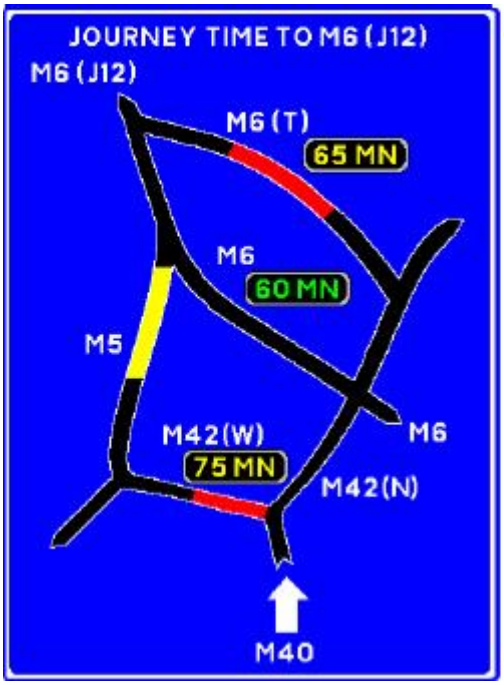
- French GRIP prototype (Highways Agency, 2003):
  

- Spanish GRIP used in Madrid area, with travel times (Highways Agency, 2003):

- 

- Proposed GRIP journey time panels in UK (two alternative prototypes), with dimensions (Highways Agency, 2003):
- 

Panel Size using Medium Font	
'x'– height'	300 mm
Sign Face Width	9475 mm
Sign Face Height	13560 mm
Area	128.45 m^2
Route Width	450 mm

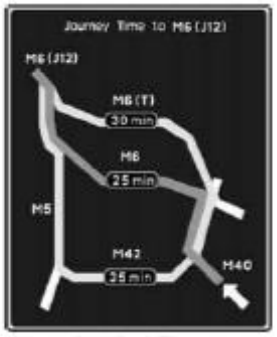
- 

Panel Size using Motorway Font for route numbers	
'x'– height'	300 mm
Sign Face Width	10385 mm
Sign Face Height	15930 mm
Area	165.46 m^2
Route Width	600 mm

44. If a graphical route map sign is used, should all road sections be color coded, or should color only be used where congestion exists?
    - Drivers may interpret blank (unlit sections) as meaning that the section of road is closed (McCabe & Valera, 2003) or that speed/travel time data is unavailable.
45. Is there any value to flashing full messages or parts of messages?
    - Dudek (2004) identifies this as a top-tier research issue, but finds that reading time may increase. None of the jurisdictions that have travel time CMS flash messages.
    - Dudek (2005) recommends language added to the MUTCD to limit or forbid flashing message elements based on research that shows show degradation of reading time/comprehension and no meaningful benefits.
46. How does driver comprehension differ between various graphical and text travel time displays?
    - Simulator study in UK by Richards et al. (2005) compared the signs shown in the two figures reproduced below. Participants viewed signs in simulated environment, then answered questions such was "what was the journey time to XX road?" and "which route was the fasted to XX town?" Signs 4 and 11 (both text-only) had the highest comprehension and recall rates. Participants also reported having the fewest problems understanding these signs. Signs 8 and 9 were considered easiest to understand, though only by a small margin.

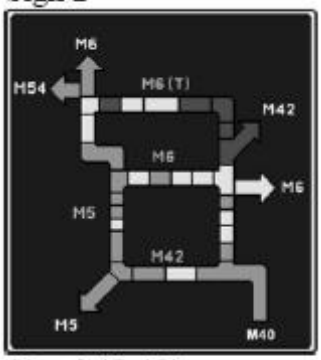
Sign 1 (existing sign)

Sign 2

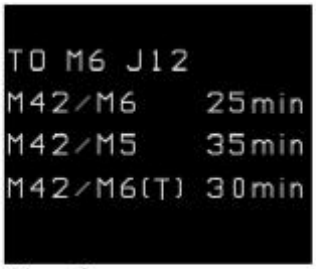


Sign 3 (& 17)

Sign 4



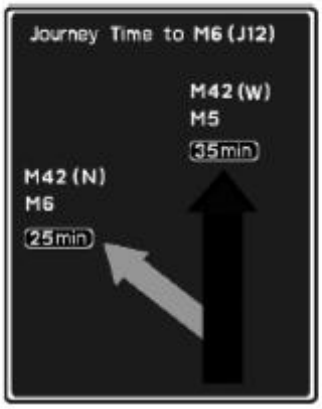
Sign 5 (& 12)



Sign 6

Sign 8

Sign 9

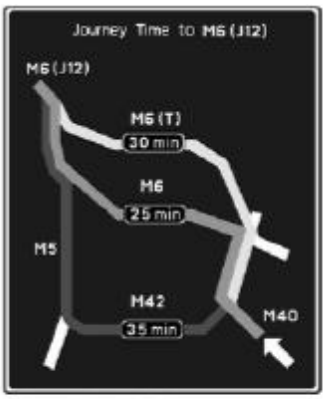


Sign 10

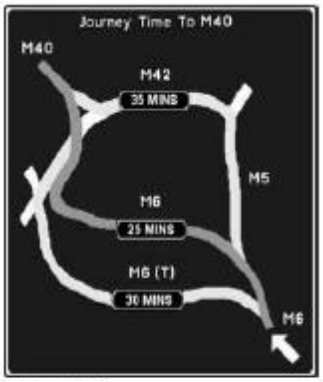
Figure 2a. Sign Designs Used in the Research Used in the Research. 17 and 12 are flashing versions of 3 and 5 respectively. Yellow and green routings are used in Sign 3and 10, while a yellow green and red scheme is used in Sign 5.

Sign 11

Sign 13

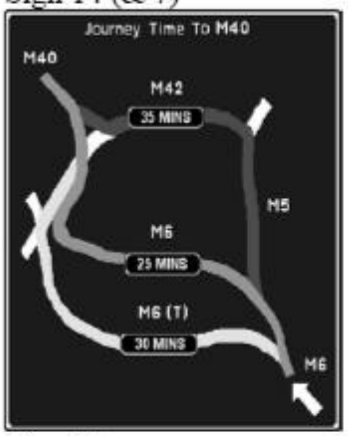


Sign 14 (& 7)



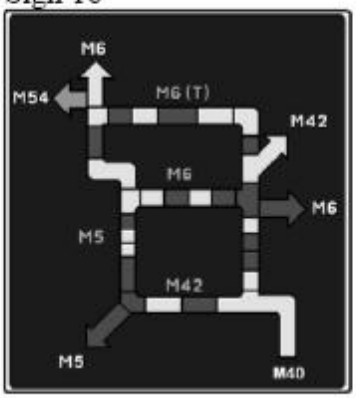
Sign 15

Sign 16



Sign 18

Sign 19



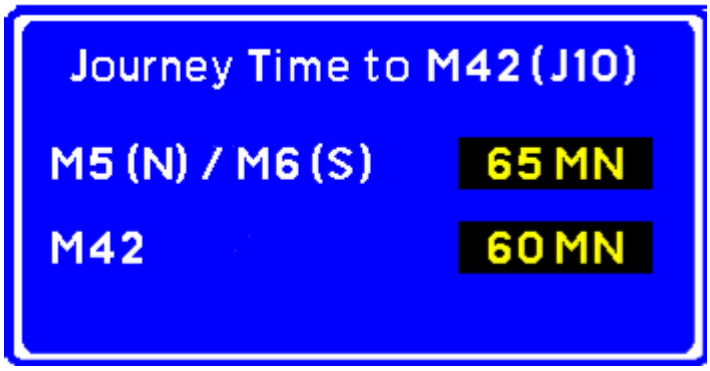
Sign 20

Figure 2b. Sign Designs Used in the Research (continued). 7 is a flashing version of 14. A yellow and green scheme is used in Sign 15, while a yellow, green and red scheme is used in signs 14, 18 and 20.

Relationship between Travel Time CMS and Static Signs

47. How can CMS and static signage be used in concert to combine benefits?

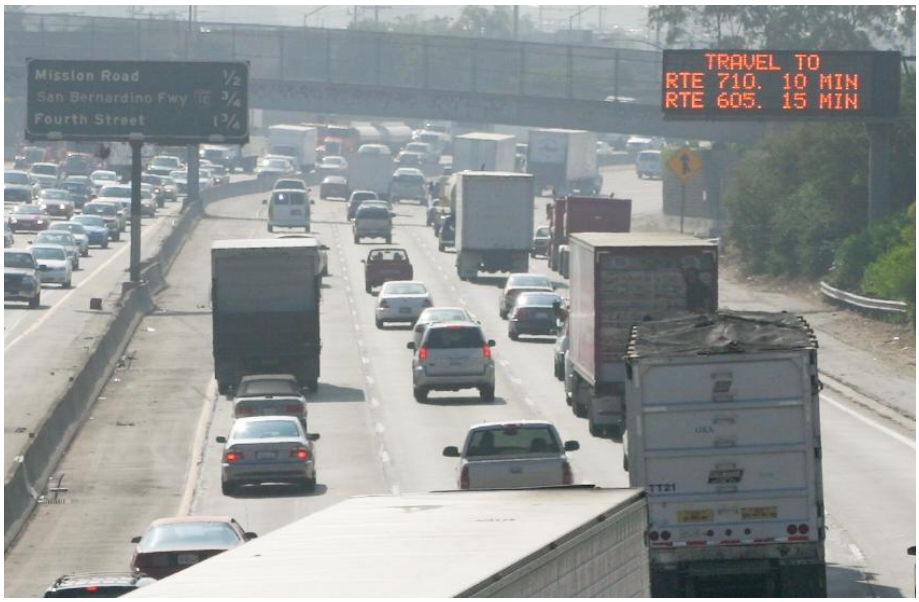
- CA initially considered posting delay time on CMS with a static roadside sign that identifies normal drive time, but rejected the idea (Lively, pc).
- Long Island is planning to implement travel time within static signage (PBS&J, 2004):
- 

- Graphical route maps, or GRIPS, typically have a static map and often have static destination text, but segments of the route or travel times can be varied.
- Wisconsin recommends that exit designations be identical to phrasing on static signage (Wisconsin Department of Transportation, 2006).
- Static signs should not be collocated with CMS because this may cause info overload (Agah, 2002).
- UK project proposed combined static/variable journey time sign (Highways Agency, 2003):
- 

48. Can travel time be used to help people coordinate (or encourage) use of other transportation modes (e.g., public transport)?
    - This is a greater concern in Europe, where more viable transit alternatives often exist, than in the U.S. (Chen, 2002).
    - In Cologne, Germany, arterial travel time is shown in contrast to other travel modes in the vicinity of park-and-ride locations to encourage people to use transit if roads are congested (see below) (Federal Highway Administration, 2006):

- 

49. Is it appropriate to collocate travel time CMS with other CMS or static signage?
    - San Antonio apparently does this:
    - 

    - So does Caltrans District 7 (photo courtesy of Jeff Aragaki)
    - 

Message Prioritization, Hours of Use, and Failure Modes

50. Where does travel time fall in the CMS message priority hierarchy?
    - "Messages advising the driver of incidents, work zones, adverse weather, environmental, and road conditions, and other emergency situations shall take precedence over travel time messages." (Dudek, 2003)
    - In virtually all jurisdictions in the U.S., travel time is the default message, but it has the lowest priority except for public service announcements (e.g., Oregon Department of Transportation, 2005).
    - Orlando CMS show travel time as a default, but show congestion information instead when congestion occurs (Heller, pc).
51. During what hours should travel times be displayed?
    - Travel time may be shown during peak and off-peak hours (Dudek, 2003).
    - Houston is capable of 24-hour operation, but typically posts travel times between 5:30 am and 7:30 pm daily, and any other time that traffic becomes congested (e.g., following an incident) (Texas Department of Transportation, 2005).
    - As of August 2005, Los Angeles shows travel time 5 am to 7 am, Monday through Friday (Caltrans, 2006).
    - San Antonio displays travel times from 6 am to 10 pm.
    - Atlanta displays travel times from 6 am to 9 pm, Monday through Friday, and 8 am to 8 pm Saturday and Sunday (Webb, 2004).
    - Idaho plans to show travel time messages only during rush hours or related to special events because congestion in the area is generally very minor (Koeberlein, pc).
    - A survey found that the public did not want travel time information when traffic was flowing freely, so Oregon Department of Transportation only shows travel times when there is congestion (Oregon Department of Transportation, 2005).
    - Nashville shows travel time all the time, unless a higher priority incident message is displayed, which happens about 20% of the time.
    - In the Milwaukee area, travel time is shown 24 hours per day (Vik, pc). This is because it is a goal to keep signs from staying blank. Doug Dembowski believes that 24-hour travel time will not lead to drivers tuning out the signs because he thinks that drivers get accustomed to the signs and begin to only look at the numbers and they are attuned to changes from the usual numbers (Dembowski, pc).
    - Chicago shows travel times during rush hours (5-10 am, 3-7 pm) and after incidents (Illinois Department of Transportation, 2005).
    - In Salt Lake City area, Utah shows messages on weekdays from 6-9 am and 3:30 to 7 pm (Utah Commuterlink website).
    - Ventura County, California shows travel time from 5 am to 7 pm on weekdays (Hoops & Gallegos, 2006).
    - Orlando shows travel times all the time in accordance with its federal grant, but would have preferred to show travel times only when drivers need them (i.e., during hours when travel times are variable and unpredictable) (Heller, pc).
    - Missouri shows travel times only during rush hours because there is very rarely any congestion at other times, so travel time would not be beneficial. It was also felt that

keeping travel times on all day would lead drivers to ignore the information because the information was not helpful most of the time (Sommerhauser, pc).

52. What should CMS show when travel time is not displayed?
    - FHWA encourages operators to not leave CMS blank; make travel time the default display; and make all new urban CMS travel time-capable. However, travel time is generally lower priority than incident reports and amber alerts. In the U.S., there are currently no CMS dedicated to travel times (Meehan, 2005a).
    - The impetus for Wisconsin's travel time implementation was largely because people complained that CMSs were often blank and seemed like a waste of taxpayer money (Langer, 2005).
    - Idaho plans to make travel time a low priority, so it will be preempted by amber alerts and traffic management messages (Koeberlein, pc).
53. If travel time information is unavailable due to system failure or because travel time information is not shown at all times of the day, what should be shown? How do drivers react to a lack of travel time information and what reasons do they attribute to the lack of information?
    - Experience in many jurisdictions suggests that drivers hate blank signs, general safety messages (e.g., buckle up), and vague information (e.g., congestion ahead).
    - In the Bay Area, if one destination is not receiving good travel time data, the line is blanked out. If both destinations are not getting good data, the entire sign is blanked out (Travel times on changeable message signs in Caltrans district 4 – system architecture and operating rules, 2005).

System Reliability and Accuracy

54. How accurate must travel time information be to gain and maintain public trust? What other factors influence perceived trustworthiness of travel time data?
    - FHWA recommends at least 90% accuracy, and never less than 80% (Meehan, 2005a).
    - For ATIS, "Across a typical trip, traffic information, such as congestion levels, should be at least 70% accurate." Local drivers may require higher levels of accuracy than drivers who are unfamiliar with an area (Campbell et al., 1998).
    - In a simulated ATIS evaluation, driver trust in the information provided was greatest at 100% accuracy, but even at 71% accuracy the information was still deemed useful. Driver performance and opinion suffered when accuracy was reduced to 43%. System inaccuracy had more detrimental effects on trust when drivers were in familiar settings (Kantowitz et al., 1996).
    - Simple algorithms are generally accurate enough without using advanced prediction models (Meehan, 2005a).
    - Oregon recommends accuracy of at least 70%; the travel time system is more accurate during free-flow conditions than during periods of congestion (Oregon Department of Transportation, 2005)
    - 70% of survey respondents in Japan felt that +/- 5 minutes is an acceptable range. Acceptable error range was insensitive to overall trip length (Chung et al., 2004).
    - In Chicago, most drivers believe that travel times are accurate even when they are not (Galas, pc).

- In a London system designed to provide bus riders with predictive bus arrival times, 65% of surveyed riders felt that their average wait time decreased after the wait time system was implemented. Riders felt that bus arrival reliability increased even though it had, in fact, decreased (Smith et al., 1994; cited in Transit Cooperative Research Program, 2003).

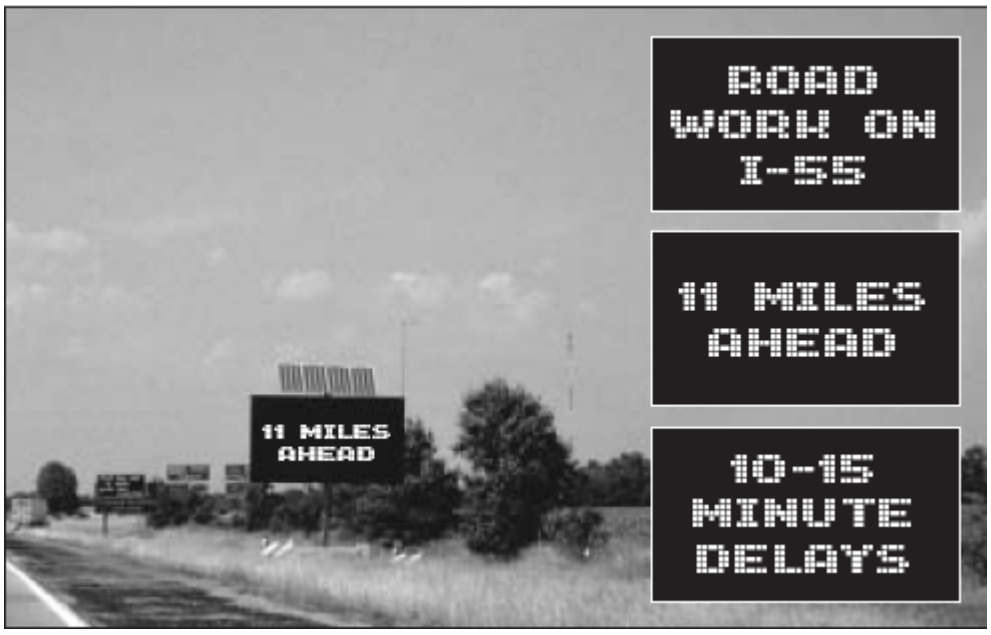
55. How does travel time credibility affect the way people use travel time information?
    - Positive perceptions of traffic information accuracy has a significant effect on whether drivers choose to comply with route guidance information (Chen & Jovanis, 1779; cited in Lerner et al., 2000; Mahmassani & Liu, 1997; cited in Lerner et al., 1998).

Mitigating Undesirable Results of Travel Time Information

56. What safety concerns do travel time messages raise? Might travel time messages lead to distraction, slowing, or unsafe driving by causing drivers to perform mental travel time/speed/rerouting calculations, pay too much attention to time (e.g., look at a watch or clock), or speed to try to beat calculated travel time estimates? Might encouraging people to divert to unfamiliar and non-freeway routes lead to an increase in crashes?
    - "Some agencies recommend that high accident locations should not be considered for VMS placement" (Enterprise, 2004, p 34).
    - A few agencies have reported drivers slowing to read travel time messages; Utah experienced traffic slowing soon after implementation (Meehan, 2005b) and Kansas City reports slowing as well as complaints of rear end crashes soon after implementation (Pinkerton, pc).
    - In Los Angeles area, traffic slowed measurably during the first days of travel time sign activity, but returned to baseline levels after two weeks (Caltrans, n.d.).
    - In California, drivers unfamiliar with travel time signs tend to slow to read signs. Locals slow down when travel times are first implemented, but grow accustomed to them quickly, though they will still slow if a novel message appears on a CMS usually used for travel time (Jenkinson, pc).
    - The majority of people who were "very dissatisfied" with travel times on CMS (36% of all survey respondents) believed that signs were causing drivers to slow down to read them (Caltrans travel time information project summary).
57. What are the best practices to prevent traffic from slowing and performing other unsafe behaviors?
    - Do not use animated/motion features because these can result in drivers looking away from the road for unsafe durations (Lerner et al., 2004).
    - Bay Area recommends seeking press coverage and posting message such as "TRAVEL TIMES COMING SOON ON THIS SIGN" a week before travel time launch (Margulici et al., 2006).
    - Shortly after starting to post travel time, Oregon Department of Transportation heard from police that drivers were slowing to read messages. Oregon Department of Transportation then began outreach campaign to educate public about travel time. They acknowledge that the outreach program should have begun before implementation (Oregon Department of Transportation, 2005).
    - In Utah, drivers slowed to read travel time messages after travel time was implemented. The problematic behavior was drastically reduced when Utah Department of

Transportation responded with a public information campaign to educate the public (Meehan, 2005b).

Presentation of Travel Time Information on Portable CMS

58. What are appropriate policies for use of travel times on portable CMS?
    - Except with rare exceptions the Gary-Chicago-Milwaukee (GCM) corridor does not allow portable CMS for travel times because space is too limited to provide detailed messages, visibility is insufficient, TMCs are generally not equipped to provide wireless real-time info to CMS not wired into system, and motorists do not expect travel times on portable CMS (GCM usage guidelines for portable CMS).
    - San Antonio has no plans to use portable CMS for travel time.
    - Roadside location may limit visibility.
    - Wisconsin demonstrated portable travel time in two work zones, but currently only use portable CMS for incident reporting, not travel time (Langer, 2005).
    - An Illinois demonstration used a 3-phase message for work zone information and delay time (see below) (Federal Highway Administration, 2004):
    - 

Presentation of Travel Time Information on Non-Freeway Locations

59. How can freeway travel time be displayed prior to entering a freeway?
    - Wisconsin shows freeway travel time on arterials like this (showing one destination in each direction of travel on freeway) (Langer, 2005):

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- Altanta area (Barrett Parkway) has at least two smaller, two-phase board that display travel time messages prior to freeway entry (phase 1 on left, phase 2 on right) (Georgia Navigator web site):
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Koeberlein, Robert	Idaho DOT	Boise, ID
Lively, David	Caltrans	State of California
Pinkerton, Troy	Missouri DOT	Kansas City and St. Louis, MO
Sommerhauser, Mark	Missouri DOT	Kansas City and St. Louis, MO
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